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Lubrication

A Technical Publication Devoted to the Selection and Use of Lubricants

THIS ISSUE

Lubrication of Hydraulic Power Generating Equipment

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Lubrication of Hydraulic Power Generating Equipment

IN the classification of power plant prime moving equipment, according to the manner in which the energy of steam, oil or water is converted into useful electrical energy, it is practicable to develop two broad groups, viz.:

Equipment such as the steam turbine or reciprocating engine, wherein fuel must first be burned under boilers for the purpose of developing steam to drive the prime mover, and,

Equipment such as the oil engine or hydraulic turbine, which serves to convert the pent up energy contained in fuel oil or by a moving body of water directly into electrical energy.

The hydraulic turbine occupies a unique position in the field of power generation, in view of the fact that it makes direct use of our water power resources. It is regarded today as a potential factor in the future development of super-power tie-ups, for it enables the generation of electrical energy without the necessity of handling materials once the water streams have been diverted to the proper channels.

It must be borne in mind, however, that the average hydraulic installation will very often be located at a point to which transportation of equipment may be a difficult matter, for the rivers which have sufficient fall to be adaptable to power generating purposes are frequently in localities unconducive to habitation.

It is, therefore, most important to protect the equipment once installed. It must be realized that any break-down may lead to considerable difficulty in transportation of any parts and the obtaining of labor for installation. Lubrication, which is the ultimate criterion in this matter of protection, must in consequence, be carefully watched.

A study of hydroelectric machinery is also of interest by reason of the size and dependability of the machinery employed, as well as the lubricating problems which may be involved.

As a general rule, these will require consideration of pressure and temperature. The matter of speed will not be so important, provided lubrication is adequately maintained to meet the existing thrust pressure.

There is also far less chance of lubricating oils becoming contaminated by dust, dirt or other abrasive foreign matter in the hydroelectric plant. Obviously this is to be expected, due to the absence of coal or other fuel, the elimination of steam generating equipment and the usual location of the plant in a region of comparatively dust-free atmospheric conditions.

Temperature fluctuation must be regarded from two angles, i.e., the extent to which abnormally high temperatures may develop through the occurrence of metallic friction and impaired lubrication, and the possibility of certain of the operating mechanisms having to function under comparatively low water temperatures.

It is important to remember, however, that in contrast with the steam turbine the only way in which abnormally high temperatures can occur is through friction; there is no possibility of external heat being transmitted to the bearings, as may occur in a steam installation. In the case of those parts subjected to prevailing low temperatures impaired lubrication will be caused by reduction in the fluidity of the oil to cause partial congealment. If a product of suitable refinement and an adequately low pour test is used, however, low temperatures will rarely give rise to inefficient operation.

In the case of pressure the dependability of a hydraulic turbine will be contingent upon the ability of the lubricant to maintain effective lubrication in the presence of the relatively high vertical pressures which will be developed in the step or thrust bearings during operation. This is, of course, aided by the use of a properly designed bearing to carry the loads involved.

The possibility of abnormal pressure, however, will be confined to the thrust bearings. The guide bearings, which serve to maintain the machine at proper alignment, will normally be subjected to but little pressure.

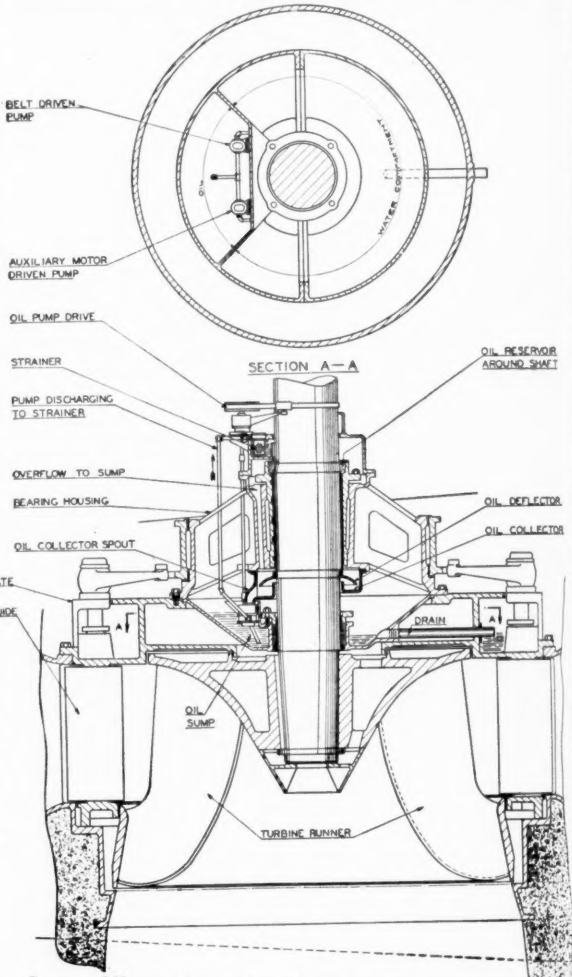
It will, therefore, be of interest to study in more detail the design of the accepted types of thrust bearings and other parts which are employed today in hydraulic turbine installations, and the requirements which they may impose upon lubricating oils or greases, as well as the manner in which these latter should be chosen to meet the operating conditions.

NECESSITY FOR PROPER LUBRICATION

The average operating conditions to which hydraulic power generating equipment may be subjected require careful study of the moving parts for the purpose of developing and maintaining as effective lubrication as possible.

In certain types of bearings, notably those which carry the weight and absorb the thrust in a vertical installation, the pressure developed per square inch may be comparatively high, ranging up to 400 or 500 pounds. The entire pressure on such a unit may amount to 1,500,000 to 2,000,000 pounds. In a large turbine it is very obvious that such pressures must be taken care of and absorbed by properly designed thrust bearings. Otherwise abnormal metallic friction may arise, to perhaps burn out the bearings.

As a result, there is a direct relationship between temperature and efficiency in operation. The efficiency of any type of thrust bearing may be said to be decidedly dependent upon the effectiveness with which it is lubricated. In fact, according to Kingsbury,*—"The rate of heat generation in the bearing



Courtesy of Newport News Shipbuilding and Dry Dock Company

Fig. 1.—Showing the lubricating system of a vertical Francis turbine. The oil supply is carried in an oil sump below the bearing. It is pumped by a geared pump upwards through a strainer and flows therefrom through an auxiliary and secondary oil reservoir above the bearing through the latter. There is an over-flow to carry excess oil back to the sump. Essential details are shown on the drawing.

films is equivalent to the power required to overcome the frictional resistance to rotation. The films are therefore continually discharging heated oil and taking in a fresh supply at whatever temperature it is available."

For this reason the matter of temperature must be given careful consideration. The problem is solved in part by the installation of properly designed cooling coils and the circulation of a sufficient amount of comparatively low temperature cooling water to bring the temperature of the oil in the bearing down to the required degree.

On the other hand, heat transfer will be dependent upon the difference in temperature between the inlet cooling water and that of

*Kingsbury Thrust Bearings, Catalog C, Page 7.

the oil in the system. It is, therefore, advisable to maintain the former as low as possible.

In connection with other parts of a hydraulic turbine installation, where grease lubrication is essential the problem of possible entry of water into the lubricating system must be considered. This holds true on the gate or valve control mechanisms and in the wheel or runner housings.

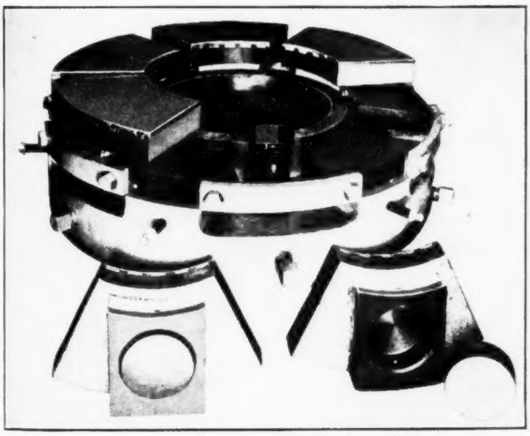
As a result, greases must not only be studied from the viewpoint of their ability to maintain a lubricating film but also the extent to which their soap content will resist going into a solution with water.

PARTS INVOLVED

In the average hydraulic turbine or water wheel installation, the parts involved will include the thrust bearings, which carry the weight of the installation, the guide or steady bearings, which serve to maintain the machine in proper alignment, the gate operating mechanisms, which are essential to the regulation of guide vanes or wicket gates in controlling the flow of water and, in some types of turbines, the wheel or runner housings. There are, however, no gears to be watched, as in steam turbine plants, nor is there the possibility of development of abnormally high bearing temperatures unless lubrication actually ceases.

Thrust and guide bearings are designed for oil lubrication. As a general rule thrust bearings are pressure lubricated, according to the size and design of the installation. Guide bearings, however, are virtually always flood lubricated by gravity.

The other elements in turn are normally designed for grease lubrication, with suitable provision for application of grease under pressure.



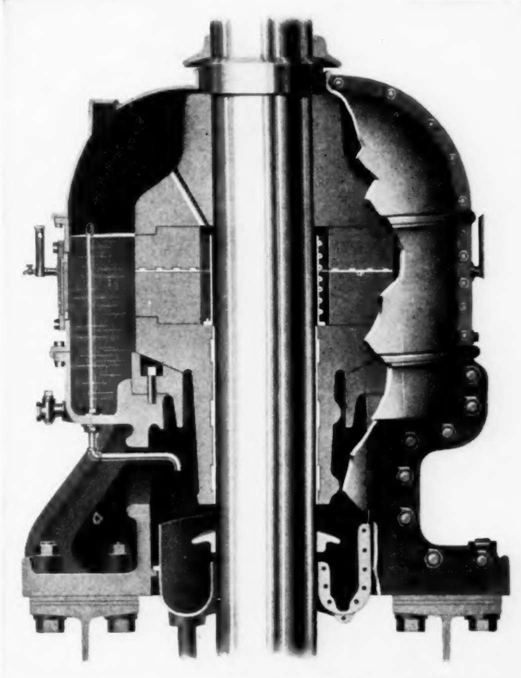
Courtesy of Westinghouse Electric & Mfg. Co.

Fig. 2—A Kingsbury thrust bearing, showing details of construction of the essential parts.

Design and Construction of Thrust Bearings

The thrust bearings in an hydraulic plant will probably be the most important bearing elements by virtue of the duty which they perform and the extent to which they may become inoperative or impaired by faulty lubrication.

Normally they will include the rotating collar type of bearing, such as the Kingsbury, the G. E. Spring type, the Gibbs or the Michell. All these bearings have a rotating collar. Opposed to this latter, however, is a fixed bearing member designed to produce oil films for the surfaces while running. The construction of this bearing member will depend upon the type of bearing. In the Kingsbury, for example, a plain collar forms one bearing member, the other being formed by pivotted shoes or segments. These latter are free to tilt both radially and tangentially by virtue of their manner of support.

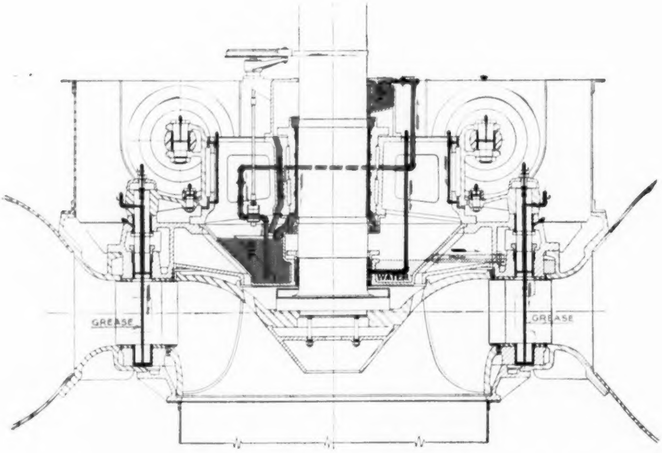


Courtesy of S. Morgan Smith Company

Fig. 3—Phantom view of a Gibbs oil bath type thrust bearing. A feature of this bearing is the positive degree of lubrication which is developed regardless of speed.

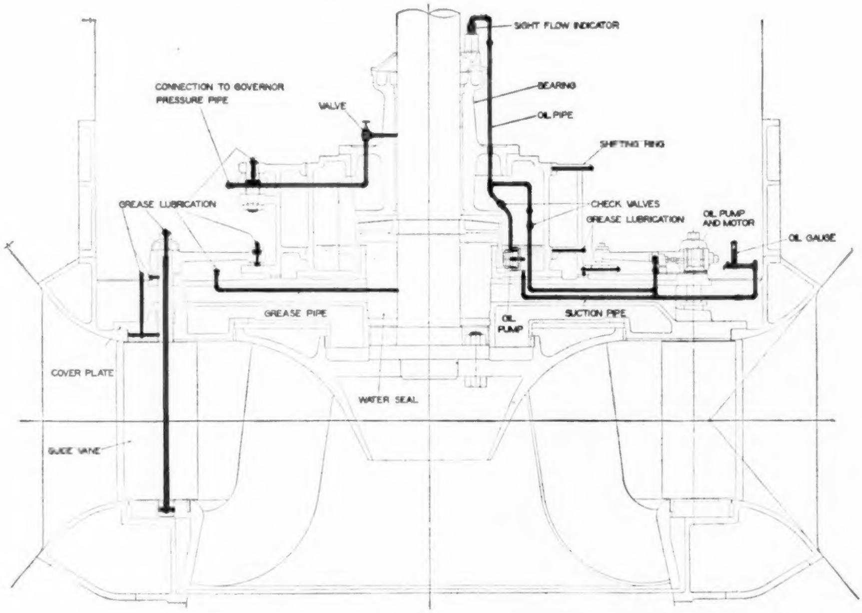
These surfaces are completely covered during operation by an oil film which will automatically change its shape and thickness to conform to the load imposed, the speed of operation, and the relative fluidity or viscosity of the oil.

The Gibbs and Michell types of bearings are very much akin to the Kingsbury in regard to principles of operation. The G. E. spring type, however, is distinctive in that it is more capable of automatic adjustment in event of misalignment. Such a bearing involves a collar or



Courtesy of Newport News Shipbuilding and Dry Dock Company

Fig. 4—Showing details of the base of a hydraulic turbine installation, bringing out the oil, grease and water connections. Oil flow is shown in red, the grease connections to the guide vane operating mechanism being shown in green.



Courtesy of Allis-Chalmers Mfg. Co.

Fig. 5—Details of an Allis-Chalmers hydraulic turbine, showing just where oil or grease is used. Red lines show the various oil piping and connections, the green indicating grease lubrication and the equipment essential to same. This drawing also shows guide vane lever bearings, the shifting ring bearing surfaces, and a grease-pack water seal.

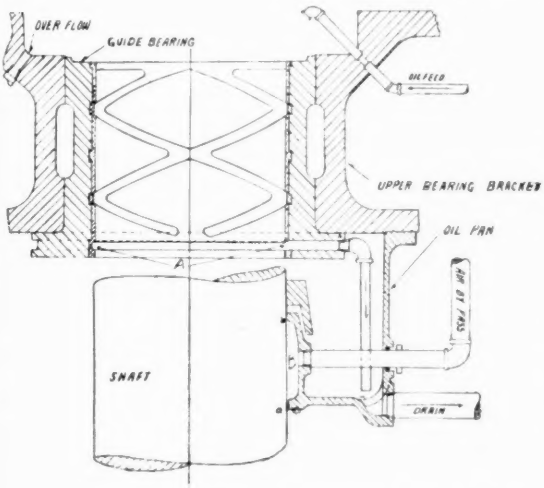
runner which rests on short helical springs, maintained in position by dowel pins on the base casting.

By virtue of the construction of the modern thrust bearing the load will be uniformly distributed, whether it is located in vertical or horizontal position. In the average hydraulic plant, however, vertical location will be more prevalent. The operating efficiency, as already mentioned, will hinge not only upon the bearing design but also upon the ability of the oil to maintain a lubricating film of adequate thickness.

In view of the fact that the thickness of the oil film will be in part contingent upon the viscosity at the operating temperature, as well as the total load, careful study of the matter of viscosity will be essential.

Frequently a small bearing of say 10,000 pounds total load will require a somewhat heavier oil than larger bearings. The matter of speed, however, must be considered in this regard, for the use of a heavy oil in a high speed bearing may involve an increase in power loss commensurate with the viscosity of the oil.

This has been admirably summed up by Kingsbury* in his handbook on thrust bearings where he states—"For low speeds and heavy loads a thick oil must be used, while for high speeds and moderate loads a thin oil is preferable. The reason for this practice lies in the thickness of the oil film. It must be great



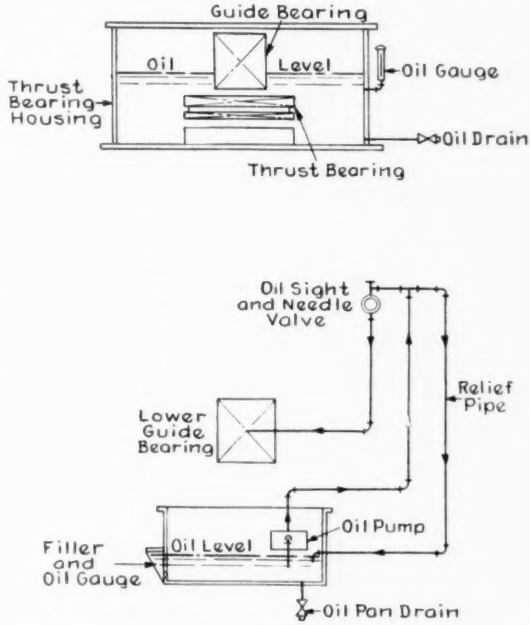
Courtesy of Westinghouse Electric & Mfg. Co.

Fig. 6—Sectional view of an upper guide bearing and details of the oiling system. The oil after passing through the bearing comes out at the bottom of the shaft and returns back to the pan. By reason of the design and the manner in which oil is returned to the pan any suction which might exist at "a" will be relieved by an air by-pass at "B" so that the possibility of oil vapor being drawn through "b" will be reduced to a minimum.

enough to separate the bearing faces. It requires a heavy oil to do this at low speed and high unit pressure, whereas a light oil will bring about an adequate separation at high speed and moderate unit pressure."

Guide and Steady Bearings

The number of guide bearings to be installed in a hydraulic installation will depend upon the length of the shaft. Usually there are three of



Courtesy of General Electric Company

Fig. 7—Showing the oil system used for a General Electric hydraulic turbo-generator. Note the combined upper guide bearing and spring thrust bearing as shown.

such bearings, one being located at the top of the generator, one directly below the rotor, and one on the top of the turbine wheel. The top bearings are babbitted. Lignum vitae, however, can also be used in the bearing above the crown plate of the turbine or wheel. Certain experiments have also been carried out using rubber for such bearings.

The advantage of the lignum vitae or rubber bearing is that it can be lubricated by means of water, although it is perfectly practicable to design such bearings for grease lubrication. Where this is to be carried out, means for forcing the lubricant to the bearing should be provided.

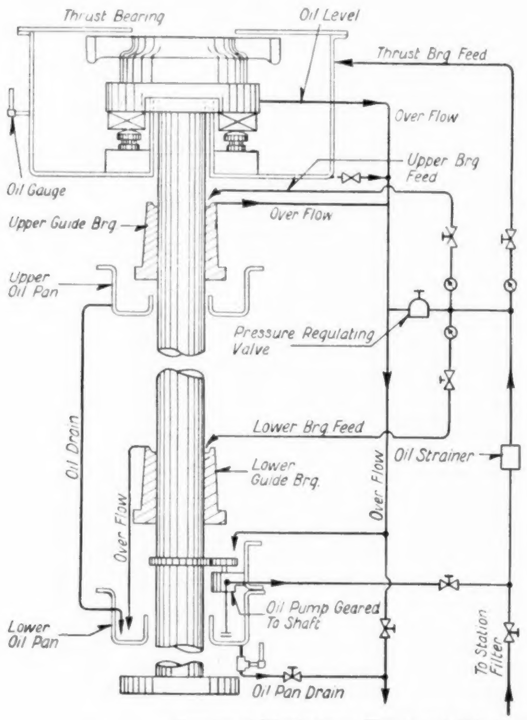
Babbitted guide or steady bearings, however, are lubricated by oil, using either gravity or mechanical pressure for the maintenance of a suitable lubricating film within the clearance spaces.

By reason of this practice, such bearings are normally designed with the lubricating systems entirely enclosed, i.e., built so that there is but a minimum possibility of entry of abrasive dust or perhaps moisture. The oil pump as an adjunct to pressure lubrication is perhaps more

*Kingsbury Thrust Bearings, Catalog C, Page 10.

satisfactory than gravity feed, due to more complete concentration of the lubricating piping and the ease with which the oil supply can be located adjacent to the bearings. In such installations the oil pump is installed within the oil pan, with suitable lines and sight feed controls to the bearings. There is a lead from each bearing to the oil pan.

It is possible to amplify such a system by installing a filter or oil purifier. In general such devices operate on the continuous by-pass method, whereby a certain amount of oil is



Courtesy of Westinghouse Electric and Mfg. Co.

Fig. 8—Showing the Westinghouse type of oiling system used in a two bearing design of hydraulic turbine. This involves a gravity over-flow, the oil being carried from the oil pump to a common header, which serves both guide and thrust bearings. This system maintains a constant head on the various bearing feed lines, regardless of the oil flowing to the individual bearings, so long as oil is running through the main over-flow.

constantly removed from the total volume in circulation and passed through the purifying device prior to return to service. It is also practicable to combine certain types of thrust bearings with the upper guide bearing, which is located on top of the generator. There is a distinct advantage in such an installation, in that lubrication can be effectively maintained by the same system.

Anti-Friction Bearings

It is also practicable to use anti-friction bearings in hydroelectric installations. Normally, however, these will be confined to the thrust element. Both ball and roller bearings have been used for this purpose. Ball bearings, however, have been found more successful on smaller types of water wheels where the total pressure involved may not exceed 10,000 pounds. Roller bearings, on the other hand, have been claimed to carry higher pressures.

SYSTEMS OF LUBRICATION INVOLVED

In hydraulic turbine service automatic lubrication will be employed. The design and construction of the means involved will depend upon the location of the parts to be lubricated.

Guide and thrust bearings are oil lubricated, as already stated, normally by some form of automatic circulating oiling system. On the other hand, it is perfectly practicable to run certain types of thrust bearings in a bath of oil, provided there is ample capacity and adequate means for water cooling of the oil in the bath.

In general construction, a pressure lubricating system will usually involve a gear or plunger type pump, located in the oil pan or reservoir, either adjacent to or below the bearing to be served. Ordinarily this pump is driven from the main shaft.

Sight flow indicators are normally installed in the distributing pipes to measure the rate of oil flow.

Where a pressure circulating oiling system is designed to serve only the guide bearings in a hydroelectric installation, the oil after passing through these bearings is returned to the oil pan or reservoir for cooling, when necessary, and recirculation.

Where the same system of lubrication is to serve both guide and thrust bearings, however, the oil is oftentimes first carried to the upper guide bearing and thrust bearing and from thence to the lower guide bearing prior to return to the oil tank.

On the other hand, it is practicable to run an individual line to this latter bearing, leading off the main distributing pipe.

While the above discussion will hold true for the average unit installation, it will be interesting to note that centralized pressure lubricating systems are extensively adapted to large installations, involving more than one generating unit.

The principle involved in a centralized pressure system will be very much the same as that explained above, with the exception that the oil pumps are independently driven and have no connection to any of the shafting. In such systems it is customary to use motor driven rotary pumps, equipped with automatic controls.

An accumulator or pressure tank is provided for each generator. This will eliminate the

possibility of pulsation or inertia within the supply lines to the various bearings.

Sometimes each unit is also equipped with its own sump tank to accumulate the oil distributed from the bearings prior to its return to the main tank of the system.

It is important to remember that where an oil pump may be driven directly from the rotor shaft, circulation of oil will start immediately when the machine is put into operation. In a centralized system, however, it might be necessary to turn the oil supply on or off with the starting or stopping of the turbine. Here there would, of course, be the possibility of waste if the oil were allowed to flow through the bearings after the unit has been stopped. On the other hand, were the oil not turned on prior to starting the resultant damage to certain of the bearings might be serious.

Grease Lubricated Parts

The parts which will require grease lubrication in a hydroelectric turbine installation will include the runner or wheel housings, and the guide vane bearings. Wherever practicable provision is made to supply these parts with grease under a certain amount of pressure.

If relubrication is carried out at regular intervals, according to the degree of motion existing in the parts to be lubricated and the ability of the grease to maintain its position within the bearing, a positive film of lubricant can be insured within the clearance spaces.

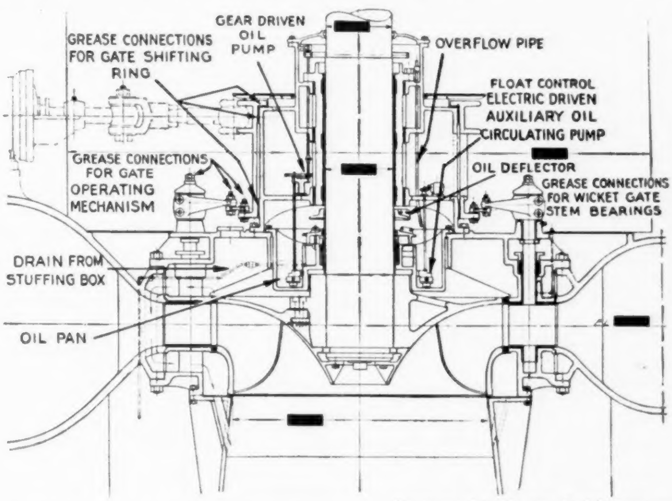
If any of these parts may be subjected to the entry of water an insoluble grease should be used. By insoluble is meant a product which can be used in the presence of water without its soap content passing into a solution, to impair the intended homogeneity and consistency of the grease.

It is important to remember that the extent to which positive lubrication can be maintained on such parts will depend upon the degree of submergence. This is one of the points affecting the use of vertical turbines with more than one runner. Where such construction is involved it is essential to submerge the gate mechanisms almost entirely, with the result that the attendant bearings cannot be dependably lubricated.

Furthermore, there are more complications involved in designing the essential parts. With the single runner type of turbine, however, the gate mechanism can be built exposed, so that there will be no possibility of any parts being in contact with water except the gates. This will enable positive lubrication of all pin connections and bearings, provided suitable means are installed for this purpose.

This matter of gate or vane lubrication has been admirably summed up by the Newport News Shipbuilding and Drydock Co., viz.:

"Next to the runner, one of the most important parts of the turbine is the gate mechanism. More moving parts subject to wear and deterioration are embodied in the gate mechanism than in all the rest of the turbine proper. All bearings should, so far as possible, be protected from the action of the water and grit which it contains, and mechanical friction should be reduced to the minimum. The latter consideration is very important, not only because it tends to improve the action of the governor, but because it reduces the wear on the various parts of the mechanism. There are from seventy to one hundred or more separate pin connections and bearings to one set of gates, and replacement of worn parts is necessarily a troublesome and expensive matter. All bearings and pin connections should be lubricated, and this cannot be done properly unless they are protected from the water."



Courtesy of S. Morgan Smith Company

Fig. 9—Cross section of a hydraulic turbine with the essential parts pertaining to lubrication indicated in detail.

LUBRICANT CHARACTERISTICS

To meet the requirements indicated above lubricants for hydroelectric turbine service should possess certain definite characteristics. It has already been mentioned that wherever greases are exposed to any possible contact with water they should be compounded with non-soluble soap.

In regard to oils for guide and thrust bearings, however, there are other requirements which must be very carefully considered.

These will involve:

(1) The extent to which the viscosity will withstand the thrust pressure
(2) The degree to which emulsibility may develop in the presence of water
(3) The fluidity of the oils under low temperature, and
(4) The relation of temperature to viscosity and proper cooling.

The Viscosity Factor

In order for an oil to lubricate it must be of the proper viscosity, for solid friction must be absolutely supplanted by fluid friction, this latter in turn being as low as possible.

The viscosity or body of the oil is the controlling element, contingent, of course, upon the clearance spaces which exist between the shafts and bearings, and the thrust elements. As a general rule, the higher the clearances and the more accurately these are expanded by chamfering of the bearing edges at the point of entry of the oil, the more easily will the rotating element be able to draw a suitable film of oil into this space. On the other hand, if the viscosity is too low the oil may not be able to withstand the bearing pressures involved, or if it is too high there may be altogether too much internal friction brought about. Either of these conditions will lead to an appreciable increase in operating temperatures.

Emulsibility

Emulsibility is indicative of the extent to which an oil will emulsify with water. This is of vital importance where turbine oils are concerned, in view of the fact that wherever an emulsion may prevail to any extent impaired lubrication may result. In fact, emulsification is in general the forerunner of sludge formation, which latter, in its turn, may ultimately lead to oil ways or other parts of the lubricating system becoming clogged.

Emulsibility is determined in the laboratory by simulating the extent to which agitation of a lubricant may occur in actual operation, and then noting the readiness with which separation of the resultant oil-water emulsion will occur. The object, of course, is to study the emulsifying tendency of the oil. There is, therefore, a distinct relation between emulsification, or the rate at which an emulsion will develop when an oil is agitated with water, and demulsibility, or the rate at which this emulsion will subsequently precipitate itself or settle out.

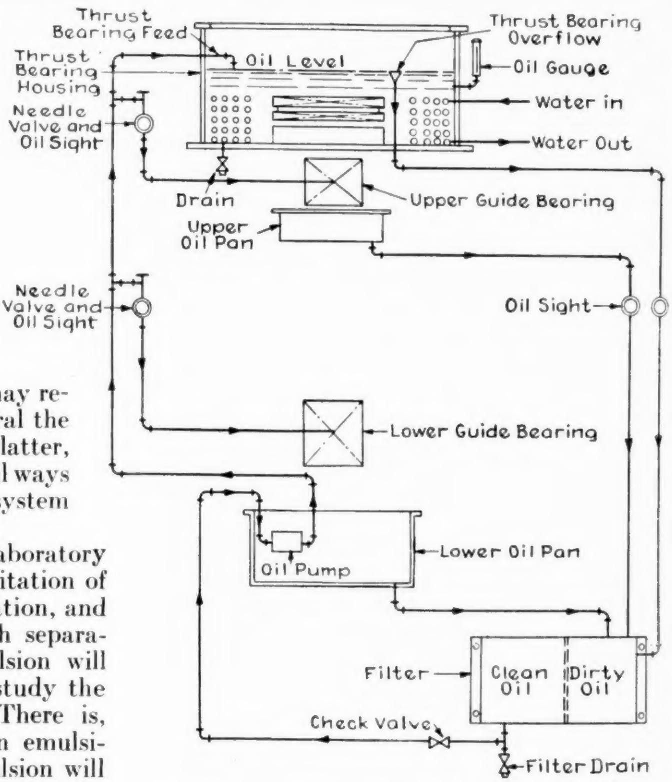
Wherever water may gain entry into a turbine lubricating system, the possibility of emulsification and the subsequent demulsibility must be given the most careful attention, not only when making initial selection and purchase of a lubricating oil, but also in its subsequent usage.

Degree of Refinement Important

Demulsibility, or the rate at which an oil will clarify itself of emulsified matter, and the completeness of this reaction will depend to a certain extent upon the base or nature of the crude from which it has been originally refined.

More particularly, however, will demulsibility depend upon the degree of refinement employed. For the more specific information of the layman this means the extent to which the oil is a straight-run product or pure distillate, the care used in fractionating or segregation of distillates of a narrow range of viscosity, and the extent to which these distillates designed for turbine service are subsequently filtered.

The use of blends, or in other words the addition of a heavier residual or distillate product for the purpose of increasing the viscosity or body of an oil, will very frequently affect the extent of separation of the subsequent product



Courtesy of General Electric Company

Fig. 10—Line sketch of a unit oiling system for hydraulic turbine service. Note that this also has a combined upper guide and spring thrust bearing.

to a marked degree, especially if filtering has not been complete.

It is well to remember that with heavier or more viscous oils emulsified matter will settle out more slowly than from more fluid products or those of lighter body. This will be especially true under the same conditions of refinement.

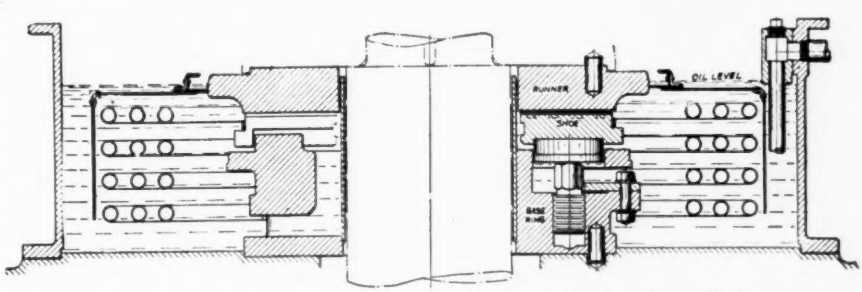
Courtesy of I. P. Morris & DeLaVergne, Inc.
Fig. 11—Showing the shop assembly of a 31,100 horse power turbine. Note the gate control mechanism.

This is one reason why a turbine oil should be of comparatively low viscosity, commensurate, of course, with other conditions, such as the operating pressures, the speed, the gallonage capacity of the lubricating system, the period of rest, and the means provided for separation of non-lubricating foreign matter.

Pour Test

The fact that the pour test is one of the most important characteristics of any oil which is to be used for the lubrication of machinery under low temperature renders a brief description advisable due to the confusion that may frequently arise in this regard, and the methods of test which are employed.

Take the so-called "cold test" for example. This has been regarded variously as that temperature at which an oil loses its fluidity, or the temperature at which solid matter commences to separate. The fact that this latter pertains directly to paraffine base oils, renders this term more or less irrelevant in respect to naphthenic or mixed base lubricants. Yet it is these latter which are most directly applicable where low temperatures may be involved.



Courtesy of Kingsbury Machine Works
Fig. 12—Showing a water cooled Kingsbury vertical thrust bearing. Note details of water piping, the oil level and the bearing elements.

In the case of paraffine base oils the "cloud test" as generally known today, is that temperature at which solid paraffine wax commences to crystallize out or separate from solution when the oil is chilled under the conditions specified for the method of test.

Were this test to be applied to a naphthenic base oil we would be dealing with that temperature just above which fluidity practically ceases. This temperature has with equal vagueness been variously termed the "melting point," "setting point" and "point of congealment."

Today, however, it is more generally known as the "pour test" where any other than paraffine base oils are being dealt with.

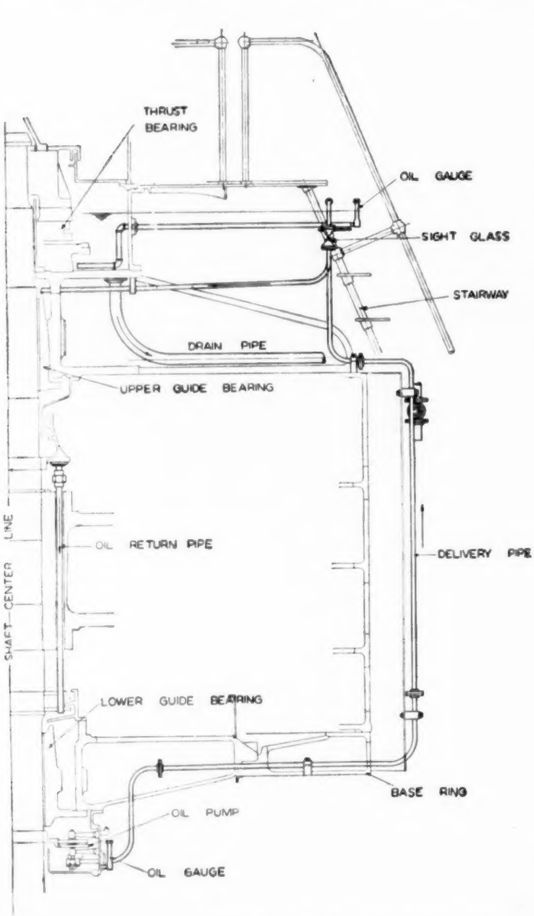
There has also been marked confusion in regard to methods of determining this temperature, and ignorance in regard to the factors which may have influence upon accurate determination. Especially is this true in regard to the preparation of the sample for test.

The effect of cold upon lubricating oils is not the same as upon simple fluids such as water, alcohol, glycerine, benzine, etc. The latter have fixed and accurately ascertainable freezing points at which a complete change from the liquid to the solid state takes place, but lubricating oils, which are mixtures of hydrocarbons of various melting points or freezing points behave like solutions, and frequently deposit some portion of their constituents before the whole mixture solidifies.

Interesting phenomena which can only be explained by changes in the inner or molecular structures, are observed in the pour test of many lubricating oils. If, for example, we take the pour test of an oil without previous heating and then take the pour test of the same oil after heating to 120 degrees Fahr., after it has cooled to the same temperature as the first, the

oil which is heated solidifies at a considerably higher temperature and the influence from preheating seems to be effective for a considerable time, at least for 24 hours. Heating to temperatures below 90 degrees Fahr., apparently has no influence.

Another factor which has an effect on the test is stirring the oil while cooling to determine



Courtesy of Allis-Chalmers Manufacturing Co.

Fig. 13—Showing complete oil piping arrangement for an Allis-Chalmers vertical water wheel generator. The essential parts are clearly indicated.

the pour test. In case an oil is stirred it solidifies at a lower temperature than when held stationary. This may be explained on the assumption that the movement of the oil destroys the formation of a fine network of microscopic particles of paraffine or naphthenic bodies which are separating out.

This segregation gives the oil a certain support and thereby facilitates solidification. In an analogous way this explanation may apply to the influence of pre-heating; the waxy or naphthenic particles are probably transformed by warming, into a very strongly dispersed state from which it is possible to form a finer and thicker network than in the oil which has not been heated.

Numerous tests have been devised to determine the pour test of lubricating oils each of which gives various and sundry results in the hands of different operators, due not only to ambiguity and lack of conciseness of the description of apparatus and method but also in the application of the methods to oils for which they are adaptable.

Committee D-2 of the American Society for Testing Materials have taken considerable pains to work out a standard method for this determination. This method, while not new in principle, is more complete in detail than any previously published. It includes a precise definition of "cloud test" and "pour test" and classifies the oils in which each or both are applicable. Attention is therefore called to the report of this committee in event of the desire to study this matter of pour test in greater detail.

PROTECTION OF LUBRICATION

Temperature Reduction

In the operation of a hydroelectric turbine lubricating system, it is essential to protect turbine oils against over-heating as well as contamination. Over-heating is guarded against by the installation of suitable cooling coils within the oil pan or thrust bearing housing, according to the design of the turbine.

Where the top guide bearing is combined with the thrust bearing, cooling water coils can be located within the thrust bearing housing. This is also practicable with a unit system of lubrication, although where all bearings are served by the same lubricating system it is equally practicable to cool the oil in the main oil pan, or sump.

It is, of course, important wherever water cooling coils are installed to make sure that all joints are absolutely water tight. Otherwise, leakage of water into the oiling system might impair its lubricating ability and lead to the formation of emulsion and sludge.

For this reason, wherever it is not absolutely essential to maintain cooling water coils in service it will oftentimes be advisable to run without water. At any rate, the amount used should not be sufficient to impose any excessive pressure within the coils themselves.

Reconditioning of Turbine Oils

In order to insure that a turbine oil will continue to function effectively and meet the several detrimental conditions of operation discussed above, it must be maintained in a suitable state of purity. This does not necessarily mean that the oil requires reconditioning until its original characteristics are brought back.

In general, operating and installation conditions will not permit of this. Experiments have proven that, unless the proportions of water, sludge and emulsified matter present are considerable, an oil will normally possess sufficient lubricating and cooling ability to function perfectly satisfactorily. Yet the oil in circulation at the time might contain a certain amount of the aforesaid recognized impurities, as well as considerable organic acidity.

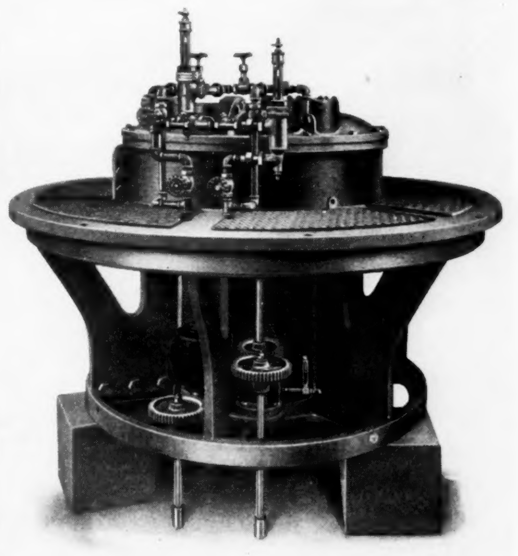
Essentially, oil purification, filtration or reconditioning have one and the same meaning and involve the removal of foreign matter which in any way may tend to impair the lubricating or cooling ability of the oil. Oil reconditioning is, perhaps, the most generally understood term and will therefore be used hereafter where reference is necessary. In its attainment, it is based on one of three distinct principles, that is, the action of centrifugal force, the separation of the impurities from the oil by virtue of difference in specific gravity, or the removal of these impurities by means of some filtering medium. Each has its respective place, inasmuch as each is particularly capable of removing certain varieties of foreign matter. For example, where finely divided carbonaceous matter is involved, which would be difficult to remove by precipitation, the addition of a certain amount of water and the subjection of the mixture to the violent action of centrifugal force, has been found to bring about a sufficiently complete state of sludge formation to

Courtesy of I. P. Morris & DeLaVergne, Inc.

Fig. 14—Showing details of an I. P. Morris vertical turbine oil bearing. Note in particular the arrangement of the oil grooves.

cause the impurities which are contained in this latter to be readily separated from the oil.

Precipitation and filtration are, in general, combined in the construction of the average apparatus which is to remove foreign matter by either one of these methods. In devices of this sort, the oil is first subjected to precipitation, oftentimes the rate at which this latter occurs being increased by heating, or by chemical or mechanical means. To a great extent, precipi-



Courtesy of S. Morgan Smith Company

Fig. 15—Showing assembly of a Babbitted turbine guide bearing, with duplicate pumps arranged for mechanical and electrical drive to insure continuous circulation of oil.

tation depends on the length of time the oil is allowed to stand in a perfect state of quietude. It is natural to expect that were precipitation to be attempted in the presence of agitation or any movement of the oil, the efforts of the suspended impurities to settle out would be interfered with. In many cases, however, it will not be possible to give the time necessary for this; therefore precipitation becomes only a preliminary separation of such larger particles of foreign matter as will settle out from the oil in a relatively short space of time.

Coming to filtration, it may be stated that it is advantageous, in that the time element is of relatively no importance. The efficiency which will be attained from filtration will of course, depend upon the type of material through which the oil is to be filtered and the rate at which it is passed. As has been said above, it is not absolutely essential to remove every trace of impurity from the turbine oil. In fact, the oil in the lubricating system always contains a certain amount of foreign matter, with the exception of perhaps the first few minutes after new oil has been put into service. As a result, it is safe to say that the extent to which an oil must be cleansed or purified should be the governing factor as to the time of precipitation and the density of the filtering medium,

or if both methods are used in combination, the relative effectiveness of each as compared with the volume of oil to be treated and the time available.

While water can often be effectively added to a turbine oil which is to be purified by means of centrifugal purification, it should not be understood that this also applies to the use of an oil filter. In other words, wet filtration, as it used to be known, or the idea of passing dirty oil through water, is now seldom used. The impurities are not removed to any extent and the oil particles will tend to absorb water, which will be difficult to remove later on. One of the most effective, though expensive, ways of bringing about the proper reconditioning of turbine oils in the least possible time is to use a centrifugal purifier in series with an oil filter. On the other hand, many plants will not care to assume the additional expense entailed in the installation of both of these devices, hence they use whichever they may have available to the best of its ability.

Whatever means of reconditioning is to be adopted, it is well to give consideration to the matter of heating the oil. As a general rule, in order to facilitate the separation of impurities by reducing the viscosity of the oil, provision is usually made in the modern oil reclaimer, whatever its type, for the application of a certain amount of heat. For example, in connection with the operation of the centrifugal purifier with the average turbine oil, it will be found that heating to the neighborhood of 150 degrees Fahr., will oftentimes aid in the separation of the foreign matter. This, of course, will also depend to a certain extent upon the specific gravity of the medium involved. On the other hand, it must be borne in mind that the application of an excessive amount of heat will tend to bring about the formation of organic acids and additional oxidation. In other words, while it may facilitate the removal of some varieties of foreign matter to a certain extent, it will also lead to the subsequent formation of others, due to the purified oil coming back into service in an acidic state.

In regard to organic acidity, it is interesting to note that of the several impurities which will usually be found in a turbine oil, it is the only one which cannot be satisfactorily removed by any of the standard forms of oil reclaimers. As yet, however, the extent to which organic acidity is directly detrimental in itself, is a point of discussion. In the opinion of authorities, even though there may be no practical means of bringing about its removal from an oil, there is a possibility that addition of water to a turbine oil, prior to centrifugal purification, will by virtue of the emulsions and sludges formed, tend to automatically reduce the amount of organic acidity. As a result, the oil which is subsequently put into the system again will be capable of going that much further, before it is once more oxidized, and sufficient organic acidity developed to bring about a dangerous amount of emulsified matter and sludge. Of course, wherever water is to be added to a turbine oil, this should be done after the charge to be purified has been drawn off or by-passed from the system. Under no condition should this be done while the oil is in circulation, due to the fact that the excess of impurities which would probably be thrown down would form a sufficient amount of additional sludge to congest the system to a dangerous extent.

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